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Two and Three Dimensional Image Registration Based on B-Spline Composition and Level Sets

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Abstract. A method for non-rigid image registration that is suitable for large deformations is presented. Conventional registration methods embed the image in a B-spline object, and the image is evolved by deforming the B-spline object. In this work, we represent the image using B-spline and deform the image using a composition approach. We also derive a computationally efficient algorithm for calculating the B-spline coefficients and gradients of the image by adopting ideas from signal processing using image filters. We demonstrate the application of our method on several different types of 2D and 3D images and compare it with existing methods.

AMS subject classifications: 68U10, 92C55, 62P10, 14QXX

Key words: Image registration, B-spline, level set, free-form deformation.

Program summary

Program title: CDMFFD image registration

Nature of problem: Find a transformation (register) between a source (moving) image and a target (fixed) image

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Software licence: BSD 3-clause licence

Programming language(s): Matlab and C

Computer platform: x86-64

Operating system: Linux, Windows and Mac OS X

Compilers: Refer to the following links for supported compilers that can interface with MATLAB:

- `http://www.mathworks.com/support/compilers`
- `http://www.mathworks.com/support/sysreq/previous_releases.html`

RAM: 8 GB recommended (more RAM may be needed for large 3D images)

Running time: Image size and computer resource dependent

1 Introduction

Image registration is the process of finding the optimal spatial transformation that maps one image to another. Image registration can be used for determining the correspondence between images taken at different times, different perspectives, or from different modalities. It has wide applications in medical imaging, remote sensing, computer vision and many other emerging fields.

In general, the registration process acquires information from the fixed and moving images for determining the transformation map. Features and the intensity of the image are the common information used for registration. The feature-based registration requires detection of salient and distinctive objects (closed boundary regions, line intersections, edges, corners, etc.) followed by establishing the mapping of corresponding features in the images. A shortcoming of feature-based methods is that they require the detection of features (which may need to be done manually), and the accuracy of registration depends on the accuracy of feature detection. The intensity-based method employs the pixel intensity levels as the information for determining the spatial correspondence between the images. The complexity of detecting the feature can thus be avoided. This method is more flexible than the feature-based registration because all the information available from the raw data is taken into consideration throughout the registration process.

Besides the type of information adopted, image registration can also be classified into rigid and non-rigid registration. Rigid registration assumes images can be aligned with one another through rotation or translation while localized stretching of an image is necessary for non-rigid registration. Non-rigid registration is useful for instances of patient motion and atlas registration applications. There are various methods for non-rigid registration [6, 11, 12, 14, 18, 21]. In particular, Thirion [18] approached the registration problem as a diffusion model. This was proven to be an approximation of a second